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Abstract
Primary tumors of the left atrium are uncommon in dogs and tumor-specific diagnoses have been made only at necropsy. No reports have been found in which the diagnosis was confirmed antemortem and the tumor removed surgically. This report describes a case of obstructive paraganglioma in the left atrium of a dog and long-term survival after surgical removal of most of the tumor using cardiopulmonary bypass. Subsequently, scintigraphy demonstrated the presence of somatostatin receptors in residual tumor in the left atrium. The latter technique may be of value in establishing a definitive diagnosis in future cases of chemodectoma, extra-adrenal paraganglioma, or adrenal paraganglioma (phechromocytoma).

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James W. Buchanan, Lynne S. Boggs, Stephan Dewan, Joan Regan, and Nathaniel C. Myers

Primary tumors of the left atrium are uncommon in dogs and tumor-specific diagnoses have been made only at necropsy.[1,2] No reports have been found in which the diagnosis was confirmed antemortem and the tumor removed surgically. This report describes a case of obstructive paraganglioma in the left atrium of a dog and long-term survival after surgical removal of most of the tumor using cardiopulmonary bypass. Subsequently, scintigraphy demonstrated the presence of somatostatin receptors in residual tumor in the left atrium. The latter technique may be of value in establishing a definitive diagnosis in future cases of chemodectoma, extra-adrenal paraganglioma, or adrenal paraganglioma (pheochromocytoma).

Case Report

A 9-year-old, 15-kg, female Brittany was referred for evaluation because of a systolic heart murmur and an episode of coughing and pulmonary crackles 10 days earlier. A CBC and serum chemistry analysis at that time were normal. A change in the character of the dog's bark had been noted earlier by the owners after the dog returned from 2 years on a Texas hunting farm. The dog was in good condition and had normal stamina when used extensively for hunting. The respiratory signs resolved after treatment with furosemide and trimethoprim sulfonamide.

Examination at the veterinary hospital of the University of Pennsylvania revealed a localized, left apical, grade 2/5 holosystolic murmur but was otherwise unremarkable. Breath sounds were normal and femoral pulses were strong. Slightly wide (0.06 seconds), notched P waves were present on an electrocardiogram. A large left atrium that compressed the left main stem bronchus was observed on thoracic radiography (Fig 1). In dorsoventral projection, the left atrial appendage was not prominent.

A 4.5 × 6.5-cm diameter, ovoid mass almost filling the left atrium was observed on 2-dimensional echocardiography (Fig 2). Color Doppler recordings showed that the mass partially obstructed forward flow through the mitral orifice (Fig 3). Spectral Doppler recordings showed sustained diastolic flow through the mitral orifice suggestive of mitral valve stenosis (Fig 4). Trivial mitral regurgitation also was noted. A tentative diagnosis was made of left atrial myxoma with ball valve obstruction. The prognosis was considered grave with no hope for survival without open heart surgery. The owners were advised to expect the dog to experience syncope or collapse within days or weeks.

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Furosemide therapy (2 mg/kg PO sid) was continued for 2 weeks at which time the owners elected to discontinue it. The dog remained asymptomatic and energetic and it was shipped to Texas and allowed to exercise without restriction. The dog was used extensively on a hunting farm for the next 4 months.

Six months after initial examination, radiographs and echocardiography were repeated in Texas. On thoracic radiographs increased pulmonary infiltrates were present, suggestive of edema in the left hemithorax as compared with the right. The left atrial mass was unchanged in size but was filling the left caudal pulmonary vein causing flow obstruction. The owners elected to have the left atrial mass surgically removed.

Cardiopulmonary bypass was achieved with bicaval cannulation for venous return and right carotid artery perfusion. A 3-headed roller pump and flat sheet, membrane oxygenator were used. The circuit was primed with 400 mL whole blood, 600 mL 5% dextrose in water, 72 mg amikacin, 900 mg ticarcillin, and 300 μg fentanyl. The right dorsal metatarsal artery was catheterized for blood pressure and blood gas monitoring.

A right thoracotomy, right atriotomy, and interatrial septotomy were used to gain access to the left atrial mass. The mass was lobulated with a smooth surface and was tightly adhered to a 1 × 1-cm sized area of the left atrial free wall. The mass was dissected free of the attachment and removed. The mass measured 6 × 4 cm and weighed 40 g (Fig 5). The histopathologic diagnosis was chemodectoma. The caudal wall of the left atrium felt thickened, but it was not surgically accessible or visible from the surgical approach used. A 5.2 × 2.7-cm mass was detected in the wall of the left atrium on postoperative echocardiography.

The dog recovered from surgery, but developed right-sided hemiplegia 24 hours later due to presumed cerebrovascular embolism. Dexamethazone (2 mg/kg IV initially, followed by 1 mg/kg IV bid) was given for 3 days. The dog also was treated with furosemide (50 mg PO bid), amikacin (4 mg/kg IV sid), and penicillin G benzathine and penicillin G procaine (Flo-Cillin®, Fort Dodge Co, Fort Dodge, IA) (50,000 units/kg for 2 weeks). Within 24 hours after the onset of hemiplegia, the dog was able to walk on textured surfaces. Conscious proprioception on the right side still was diminished and knuckling of the right front paw was present.

Four days after surgery, the dog's respiration rate and effort increased. Inspiratory crackles were heard over the ventrocaudal right thorax. Arterial blood gas disclosed marked hypoxemia (P_{O_2} = 67 mm Hg). Supplemental nasal oxygen produced little improvement in oxygenation. On thoracic radiography there were mild pulmonary infiltrates suggestive of edema. The interatrial septum appeared intact on echocardiography. A presumptive diagnosis of pulmonary thromboembolism was made. Eight days postoperatively, there was no improvement in oxygenation (P_{O_2} = 52 mm Hg), but the dog no longer tolerated the nasal oxygen tube and repeatedly pulled it out. Inasmuch as there was no increase in respiratory rate, the supplemental oxygen was discontinued. Throughout this episode, the dog continued to eat well and was responsive.

One month later, mild hypoxemia still was present (P_{O_2} = 90 mm Hg), but the dog appeared clinically normal. The owner was advised that the dog should not be flown back to Pennsylvania due to the concern about available ambient oxygen at high altitude. The dog was returned to the hunting farm where its exercise was unrestricted.

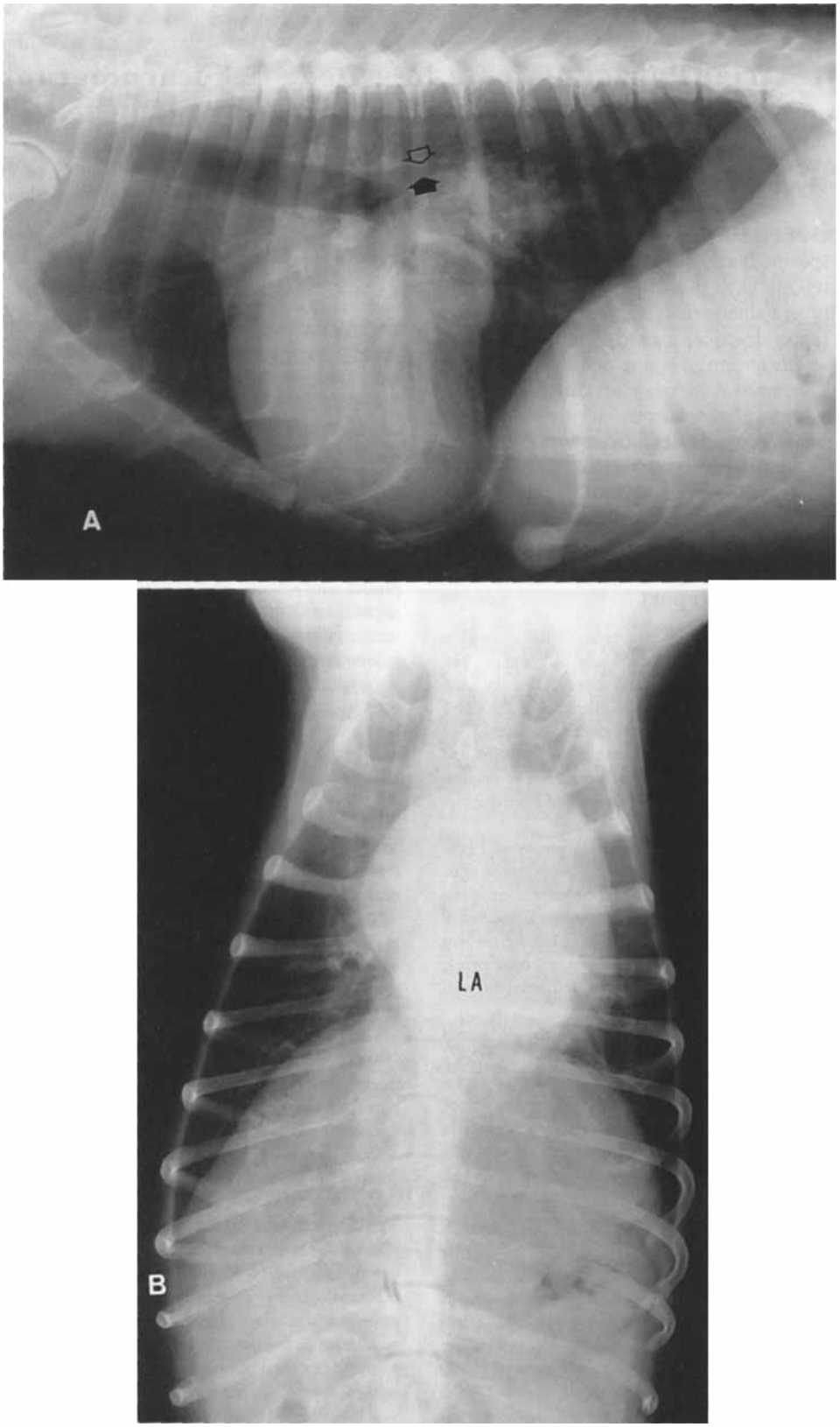

Fig 1. **(A)** Right lateral radiograph. The dorsocaudal border of the heart is enlarged in the region of the left atrium and the left mainstem bronchus is compressed (arrows). **(B)** Dorsoventral radiograph. The left atrium (LA) is more radiopaque than normal.

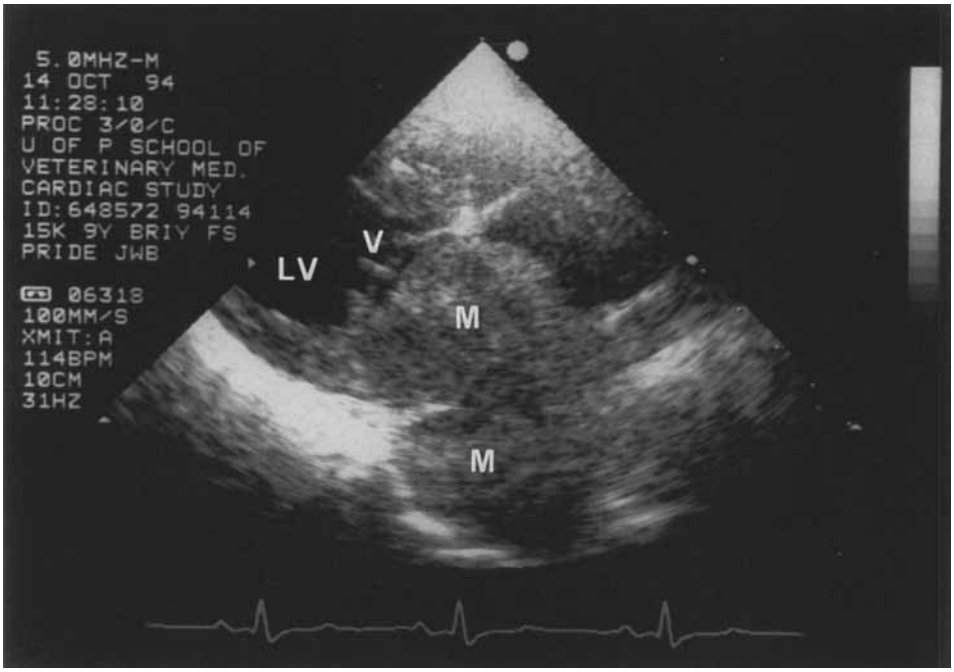

Fig 2. Two-dimensional echocardiogram. Right parasternal, long axis view. A 4.5 × 6.5-cm, homogeneous mass (M) appears to fill the left atrium and extend into caudal pulmonary veins. LV, left ventricle; V, mitral valve.

On reexamination 2 months after surgery, minimal weakness was present in the right foreleg. No heart murmur was auscultated, but an occasional arrhythmia was detected. The arrhythmia was not detected on electrocardiography. Respiratory rate (14/minute) and oxygenation (Po_2 = 96 mm Hg) were within normal limits. At this time, the dog was returned to Pennsylvania.

The dog was reexamined 12 months after initial examination (6 months postoperatively). It had mildly reduced exercise tolerance for 1 month and slept more, but was otherwise in good condition except for occasional coughing. There was occasional knuckling of the right front paw and minor ataxia of the hind legs with inappropriate paw crossing when moved in a tight circle. The heart sounds were normal.

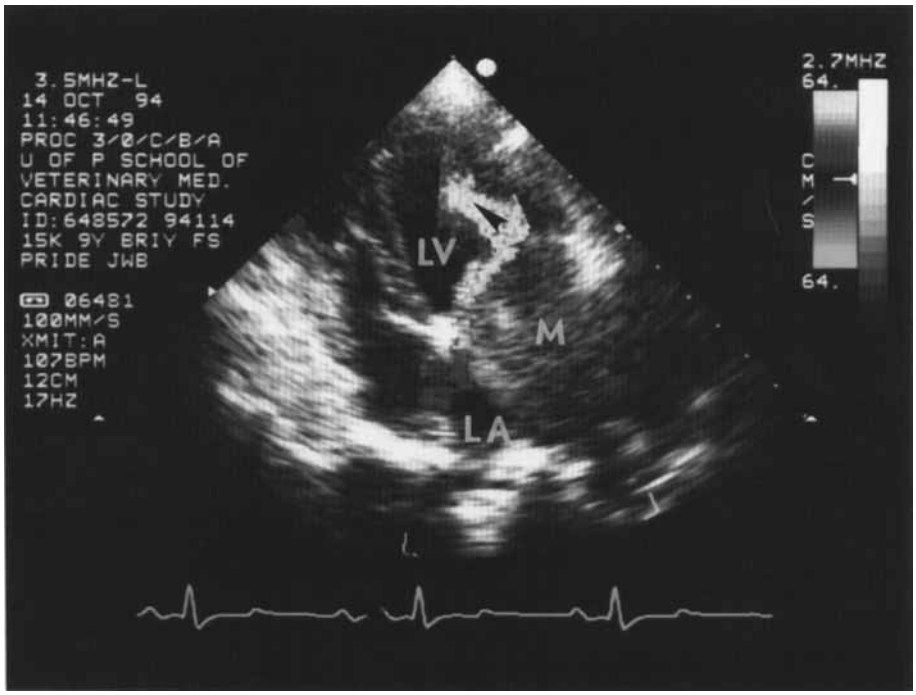

Fig 3. Color Doppler 2-dimensional echocardiogram. Left apical view. The 5-cm-diameter ball-shaped mass (M) in the left atrium (LA) partially obstructs mitral inflow (arrows). LV, left ventricle.

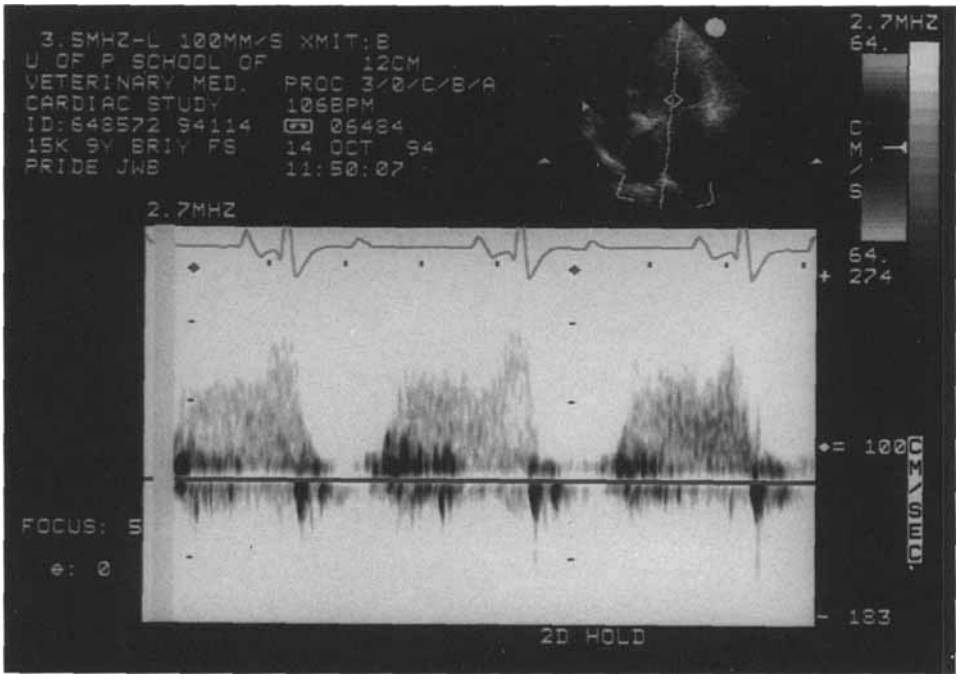

Fig 4. Continuous wave spectral Doppler of left ventricular inflow, from the left apex. The sustained diastolic, positive-velocity, Doppler signal indicates mitral inflow obstruction.

The lungs had low frequency inspiratory crackles over the area of the previous thoracotomy. The electrocardiogram disclosed slightly wide, notched P waves with occasional atrial premature beats. On thoracic radiography, the heart size was smaller than preoperatively, but moderate left atrial enlargement and left bronchus compression still were present. Tumor metastases were not evident. On echocardiography, a 2.5-cm-diameter left atrial mass extended inward from the caudal wall of the left atrium (Fig 6). The mass was approximately equal to the remaining lumen size of the left atrium, and the mass was notably larger than immediately after surgery. It did not obstruct the mitral valve.

Six weeks later, clinical signs and clinical examination findings were unchanged, and the dog was admitted for scintigraphy. Four millicuries of ^{111}indium-labeled pentetreotide (OctreoScan®, Mallinckrodt Nuclear Medicine, St Louis, MO) was injected IV and 3-minute planar images were obtained at 4 and 24 hours. Intense activity in the thoracic cavity, in the location of the left atrium, was demonstrated at both imaging periods (Fig 7). Normal dogs do not demonstrate significant uptake of

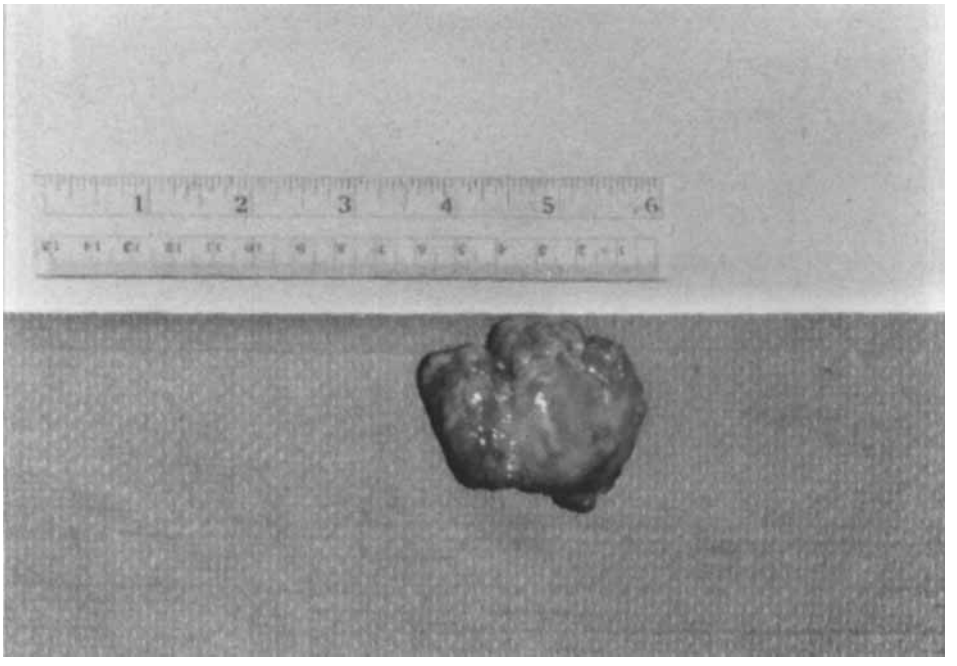

Fig 5. Photograph of the resected tumor, which measured 4 × 6 cm and weighed 40 g.

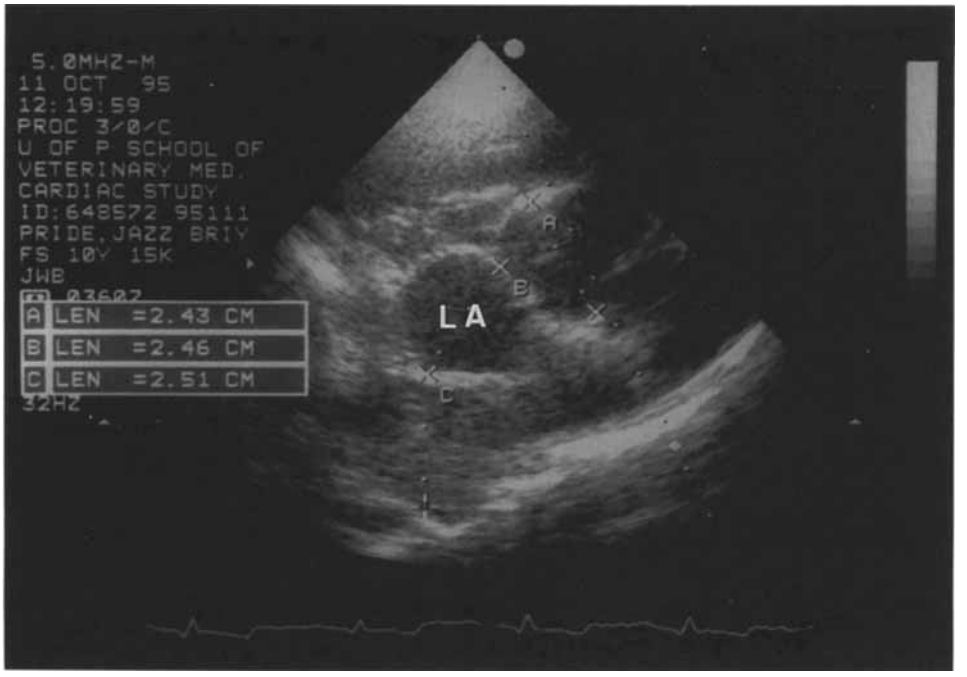

Fig 6. Two-dimensional echocardiogram 6 months after surgery. Right parasternal, short axis view. The left atrium (LA) above the mitral annulus is still free of tumor. The dimensions of the aorta **(A)**, left atrium **(B)**, and caudal atrial tumor mass **(C)** were nearly equal.

OctreoScan within the thorax. Within the abdomen, activity was demonstrated in the bladder and kidneys, as expected with renal excretion of the radionuclide. No activity was noted in the brain, liver, or lungs to suggest tumor emboli or metastatic lesions. After 48 hours to allow radionuclide elimination, the dog was discharged in good condition.

The dog was reexamined 12 and 18 months after surgery and no significant clinical signs were observed. Electrocardiograms were normal, but echocardiography and thoracic radiography indicated enlargement of the tumor on the caudal aspect of the left atrium. Twenty-one months after surgery, the dog developed ascites and began coughing. Furosemide therapy (50 mg PO bid) was initiated and the ascites and coughing were improved but still present. Two years after surgery the dog was presented for euthanasia because of moderate ascites and the owners' concern that the dog was uncomfortable. On physical examination the heart sounds were normal. Coarse pulmonary crackles were heard bilaterally over the ventral lung fields. An electrocardiogram

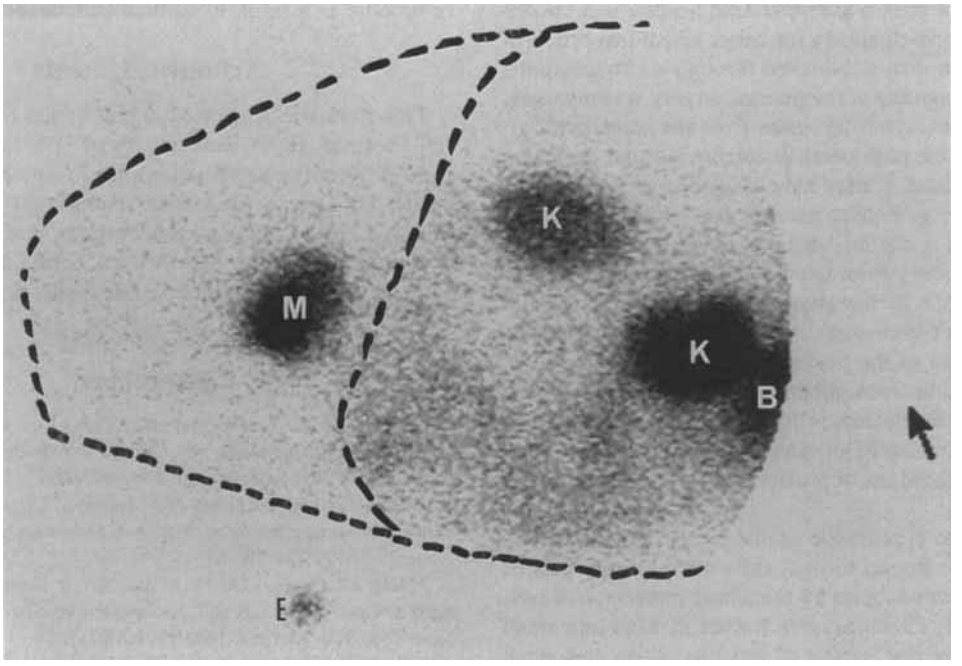

Fig 7. Right lateral scintigram 7 months after surgery. Chest and abdomen 4 hours after injection of ^{111}indium-labeled pentetreotide (OctreoScan). M, left atrial mass; K, kidney; B, bladder; E, extrathoracic radioactive marker positioned near the left cardiac apex. Dotted lines indicate the thorax and diaphragm.

indicated sinus tachycardia with a heart rate of 210/minute and no arrhythmias. On echocardiography the majority of the 6-cm tumor mass was observed to be caudal to the left atrium. The portion of the mass extending into the left atrium was only 2 cm in diameter and did not obstruct the mitral valve. On thoracic radiography, a large left atrial silhouette merged with the tumor mass. Pulmonary infiltrates consistent with pulmonary edema were observed in the left caudal lung lobe.

At necropsy, 1.5 L of serosanguineous fluid were present in the abdomen. Pleural and pericardial adhesions and atrial myocardial fibrosis were observed and thought to be associated with the prior surgery. The heart base mass was confirmed to be paraganglioma. It measured 10 × 7 × 5 cm and was mostly external to the left atrium. The mass extended around and between the pulmonary artery branches and mainstem bronchi and formed a ring around the hilar area of the left lung lobes. It extended into the left atrium as a smooth-surfaced mass 2.2 cm in diameter. It also extended into all 3 tracheobronchial lymph nodes with the largest lymph node having dimensions of 4.2 × 1.6 × 1.9 cm. A 0.5-cm-diameter metastatic nodule was present in the right middle lung lobe. A focal periventricular cholesterol granuloma was present in the thalamus of the brain. The kidneys had 3 healed infarcts. Chronic passive congestion was noted in the liver.

Discussion

In humans, slow-growing left atrial neoplasms usually are myxomas, and this was the presumed diagnosis in the present case.[3] A surprising clinical aspect in this case was the ability of the dog to exercise vigorously for months after recognition of a large, nearly obliterative left atrial mass. It was predicted that, due to the size and position of the mass just above the mitral valve, it would act as a ball valve and reduce diastolic flow through the mitral orifice to an extent that would cause syncope or left heart failure. Surgery was performed 6 months later, even though the dog was still asymptomatic, because the mass was likely to cause severe circulatory impairment at some time. The surgical approach through the right atrium and interatrial septum was chosen because this approach allows for better visual inspection of the atrial septum than is achieved through a left atriotomy. The tentative diagnosis at the time of surgery was myxoma, which, in humans, typically arises from the septal wall.[3]

The cause of the postoperative cerebrovascular occlusion was not determined. It may have been due to thromboembolism or tumor embolism because the cut surface of the mass remaining in the left atrium was very rough and friable. Rapid recovery from hemiplegia and absence of scintigraphic evidence of metastatic neoplasia 6 months later suggested that cerebrovascular thromboembolism was the most likely cause of the postoperative neurologic episode. The focal granulomatous inflammation with cholesterol deposits and multinucleated cells in the thalamus found at necropsy was considered an old infarct, and may have been responsible for the signs of postsurgical cerebrovascular occlusion.

The histologic appearance of the tumor was typical of chemodectomas. Round to oval cells were closely packed and subdivided into lobules by branching trabeculae of connective tissue. The lobules were further divided into small compartments by fine septae of reticular fibers and small capillaries. The tumor cells had centrally placed round nuclei, clumped chromatin, and cytoplasm that was basophilic and faintly granular. Mitotic figures were rare. Chemodectomas are extra-adrenal paragangliomas that originate in the carotid or aortic chemoreceptor bodies.[4,5] When located elsewhere they usually are classified as extra-adrenal paragangliomas.[6] In the present case, the neoplasm was classified as an extra-adrenal paraganglioma because the principal attachment site was in the caudal wall of the left atrium, and there was no involvement of the caudal area of the aorta or pulmonary trunk in the aortic body region.

Somatostatin receptors have been demonstrated in a wide variety of neuroendocrine tumors in humans, including pancreatic islet-cell tumors, intestinal carcinoids, oat-cell pulmonary tumors, brain tumors, pituitary tumors, pheochromocytomas, and paragangliomas. Recently, radiolabeled somatostatin analogues have been used to image tumors of the diffuse neuroendocrine system in humans.[7] Pentetreotide (OctreoScan) is an 8 amino acid analogue of somatostatin with diethylenetriaminepentaacetic acid (DTPA) complexed to the amino group of the *N*-terminal residue of the peptide. OctreoScan is closely related to the synthetic somatostatin analogue octreotide used for the treatment of acromegaly and other hormonally active endocrine tumors in humans.[8] OctreoScan is cleared by the kidneys, similar to what is observed with ^{111}indium-labeled DTPA used to evaluate glomerular filtration rate (NC Myers and JJ Hoskinson, unpublished data). Nuclear scintigraphy was performed to assess the residual tumor for evidence of somatostatin receptors, and to evaluate for evidence of metastases.

Results in the present case indicate that scintigraphy may be useful in the differential diagnosis and prognosis of cardiac tumors in dogs. The slow-growing, relatively benign nature of the neoplasm in this dog may be contrasted to the aggressive, malignant nature of hemangiosarcomas, which are the most frequent cardiac neoplasms observed in dogs. Hemangiosarcomas usually cause death within a few weeks or months as a result of cardiac tamponade or metastases.[1]

Acknowledgments

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